

WATER CHEMISTRY AND ROCK PERMEABILITY CHANGES AROUND NUCLEAR WASTE EMPLACEMENT TUNNELS

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RESEARCH OBJECTIVES

This project investigated coupled thermal, hydrological and chemical processes that could take place around waste-emplacements tunnels (drifts) at the potential high-level nuclear waste repository at Yucca Mountain, Nevada. In the unsaturated fractured volcanic tuffs around emplacement drifts, water is held mostly in the rock matrix pores. Upon heating, due to waste decay, water boils and travels as vapor in fractures. In cooler regions, it condenses and may drain back towards the boiling zone. This continuous boiling and refluxing of water, together with percolating rain water, may cause mineral precipitation and dissolution. An objective of this study was to evaluate to what extent such processes would alter rock permeability and water flow around drifts. Another objective was to predict the composition of water and gas that may enter the drifts.

APPROACH

Numerical simulations were performed using a modified version of the TOUGHREACT code developed at LBNL by T. Xu and K. Pruess. The model considers water, vapor, air and heat transport; reactive gas, mineral and aqueous phases; porosity-permeability-capillary pressure coupling; and dual permeability (fractures and rock matrix). A 2-D vertical and symmetrical half-drift model was developed that incorporated water chemistry and hydrogeologic data from field studies. The heat load due to waste package decay was imposed inside the drift.

ACCOMPLISHMENTS

Simulations were conducted over a 100,000-year time period, including possible climate changes, and two geochemical systems. Maximum dryout was predicted to occur approximately 600 years after waste emplacement, and, depending on the infiltration rate, extended to a radius of 10 to 25 m around the drift. Rewetting at the drift crown, due to meteoric water infiltration, was predicted to occur after 1,000 to 2,000 years, with return to ambient temperatures within 50,000 to 100,000 years. Calculated water and gas compositions varied depending on infiltration rates and the geochemical system considered. During rewetting at the drift crown, predicted pH in fracture water for various cases varied between 7.2 and 9.8. The water salinity typically remained less than 1,000 ppm. Calculated porosity changes around the drift due to mineral precipitation and dissolution were found to be negligible ($< 0.1\%$) for all infiltration rates considered, with more mineral precipitation occurring than dissolution after 10,000 years (Figure 1).

SIGNIFICANCE OF FINDINGS

The small calculated porosity change is predicted to have essentially no effect on the rock permeability around drifts. This conclusion differs from results of more simple modeling and experimental studies predicting possible sealing from mineral precipitation around waste emplacement drifts. The predicted water composition is of low salinity and near neutral to alkaline pH, a finding that is favorable for the performance of waste canisters and other in-drift engineered systems. More work is underway to reduce the uncertainty of the model and evaluate how this uncertainty affects the con-

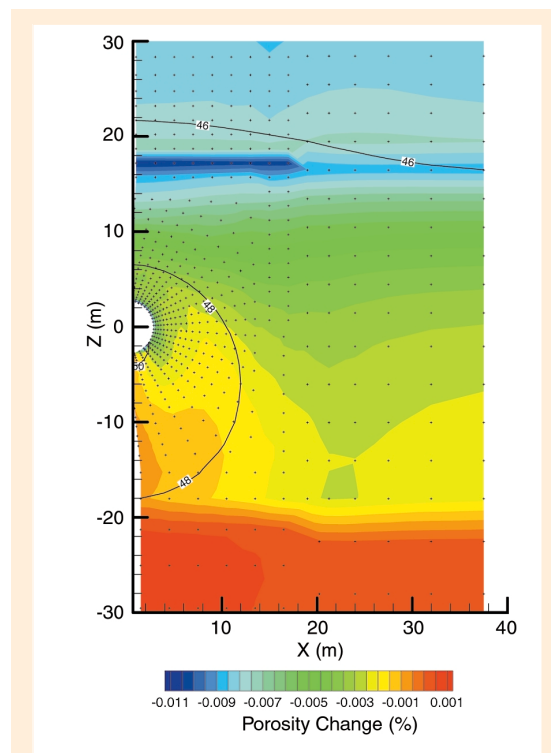


Figure 1. Modeled total fracture porosity change at 10,000 years (mean infiltration case). Blue areas show zones of maximum mineral precipitation (primarily calcite and zeolites). Temperature contours are superposed.

clusions drawn from the model results.

RELATED PUBLICATIONS

Sonnenthal, E.L., and N.F. Spycher, Drift-scale coupled processes (DST and THC seepage) models, Analysis/Model Report N0120/U0110, MDL-NBS-000001, Lawrence Berkeley National Laboratory, Berkeley, Calif., 2000.

ACKNOWLEDGEMENTS

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